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Diabetes Mellitus in Urban and Rural Communities in Papua New Guinea

Studies of Prevalence and Plasma Insulin

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Summary. Oral glucose tolerance tests (75 g) in 185 urban residents of Port Moresby and 105 ethnically similar rural villagers showed that 15.8% of urban residents had diabetes mellitus (two hour plasma glucose > 11.0 mmol/l and a total of 22% were glucose intolerant (plasma glucose > 9.0 mmol/l), compared with 1.0% and 5.5% in rural people. – Urban men and women were significantly fatter than rural people, but within each population glucose tolerance was not significantly related to weight or to age, although the numbers of old people studied were small. Compared to Australians the Papua New Guinea subjects had a higher fasting plasma insulin (16.5 vs 10.7 μU/ml, $p = < 0.05$); independent of weight fasting plasma insulin was significantly higher in the rural than urban people studied. After the glucose load, plasma insulin and glucose levels were positively correlated in rural people. In contrast, for the urban group the relation best fitted a quadratic function, with decline in plasma insulin at high levels of glucose. – The prevalence of diabetes in urbanised Melanesians in Papua New Guinea appears similar to other South Pacific countries.

Key words: Diabetes mellitus, epidemiology, Melanesians, Papua New Guinea, urban-rural, insulin secretion, fasting hyperinsulinaemia.

Papua New Guinea is a recently independent nation of predominantly Melanesian people which comprises approximately one half the island of New Guinea and many neighbouring islands, including Bougainville and New Britain. The country is tropical (latitude 3–11° South), and fertile, but with many areas of mountainous sparsely populated jungle. In the last 30 years there has been extensive Westernization of a primitive people with urbanization and considerable agricultural and mining development. This has been summarized by one political leader as "Ten Thousand Years in a Life Time" [1].

A high prevalence of diabetes mellitus has been recognised in neighbouring Polynesian and Micronesian countries following similar social changes [2, 3, 4, 5, 6], but in the absence of adequate data of the prevalence of diabetes in Papua New Guinea, it has been suggested that diabetes is rare in Melanesians [2]. The only studies of diabetic prevalence in Papua New Guinea are those of Price in the early 1960's, using glycosuria with glucose tolerance confirmation. He found a very low prevalence in rural and newly urbanized people in the Port Moresby district, but up to 1.4% in a long urbanized suburb of Port Moresby [7].

The aim of the present study was to determine the prevalence of glucose intolerance and diabetes mellitus in Melanesians living in the city of Port Moresby and in a rural village whose inhabitants were of similar ethnic origin.

Methods

The investigation was performed in the two centres in August and November 1977. The people studied were Melanesians whose origins were from villages from the South-East coast of Papua New Guinea.

The rural village of Kalo is approximately 100 km South-East of the city of Port Moresby. Contact is maintained by road transport for most of the year, except in the wet season. The resident population of the village was estimated at 380 adults in 130 houses. The people were predominantly engaged in subsistence farming or fishing, but trade stores stocked rice, tinned meat, fish, fruit and biscuits. Many of the younger men were working in Port Moresby at the time of the study. After an initial approach to the village leaders, a personal house to house invitation was issued to

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Table 1. The number of males and females in both urban and rural communities tested in different age groups with mean ± SD plasma glucose two hours after a 75 g oral glucose load

Urban (n = 185)	Males n	%	Mean 2 hour plasma glucose mmol/l	Females n	%	Mean 2 hour plasma glucose mmol/l
18–34	79	(57)	6.3 ± 3.6	23	(50)	8.6 ± 6.0
35–54	58	(42)	8.2 ± 5.2	20	(43)	8.5 ± 4.9
55 and over	2	(1)	6.7 ± 1.4	3	(7)	5.8 ± 1.1
	139			46		
Rural (n = 105)	Males n	%	Mean 2 hour plasma glucose mmol/l	Females n	%	Mean 2 hour plasma glucose mmol/l
18-34	9	(22)	5.3 ± 1.5	31	(48)	5.6 ± 2.0
35–54	23	(58)	4.9 ± 2.0	22	(34)	5.1 ± 1.4
55 and over	8	(20)	5.7 ± 1.5	12	(18)	5.8 ± 1.9
	40			65		

all adults to attend for testing. One hundred and five adults 18 years and over, an estimated 28% of the adult population were tested; these comprised 40 males (39%) and 65 females (61%). No member of this village was known to have diabetes mellitus.

The urban group of similar ethnic origin were permanently resident in a relatively affluent suburb of Port Moresby (Koki). Invitation to attend for study was made by notice following discussion with local leaders. One hundred and eighty five adults over the age of 18 were tested, comprising 139 men (75%) and 46 women (25%), (including two males with known diabetes). The number tested was estimated by house count census to be approximately 30% of the resident adult population.

Survey Procedure

Subjects were asked to attend fasting between 0800 and 0900 h. They were interviewed in English or by a dietician or medical student in Motu to obtain data on age, parity, occupation, education, known family history of diabetes and weight. Venous blood samples were taken fasting and two hours after drinking 75 g of glucose. Heparinized blood samples were centrifuged immediately and plasma stored on ice until frozen within four hours after collection. Plasma glucose was measured by one technician in duplicate in the Biochemistry Department of the Port Moresby General Hospital using the o-toluidine method [8]. The assays were performed in batches with standard sera and random samples were repeated with good duplication. The remainder of the plasma was forwarded frozen to Melbourne by air freight for measurement of immunoreactive insulin by charcoal separation [9]. Details of diets, blood pressure, plasma cholesterol, triglycerides and uric acid will be published elsewhere. Body mass index was calculated as weight kg/(height)^2 cm.

Dietary analysis was performed by recall in over 80% of subjects tested in the two groups. The rural people ate a largely traditional diet in which yams, cassava and bananas were most commonly consumed, with very little refined food; in contrast; the urban population ate a largely Western diet in which bread, polished rice and tinned foods were most common. The great majority of the urban people belonged to the Seventh Day Adventist Church and alcohol consumption was low in both groups. By preliminary estimates mean total calorie intake was approximately 2,300 Calories for urban and 1,400 Calories for rural people.

Before the test all subjects were asked if they had eaten and some confirmation of the fasting state was obtained by finding that plasma triglycerides in both groups were very low: 0.59 ± 0.34 and 0.64 ± 0.23 mmol/l (mean and SD). Statistical and data analysis was performed with an on-line version of the SPSS computer package using ANOVA, regression and correlation procedures in addition to Student's t test. Results are expressed as mean ± standard deviation unless otherwise specified.

Results

The details of the populations studied are shown in Table 1 together with mean plasma glucose by age, two hours after the 75 g glucose load. The age/specific prevalence of glucose tolerance for different ages in the urban and rural populations studied is shown in Table 2. In the urban population, the prevalence of glucose intolerance, as defined by a plasma glucose two hours after a 75 g glucose load of > 9.0 mmol/l was 22%, which is comprised of 6.3% of the population between 9.0 and 11.1 mmol/l and 15.8% with diabetic values of > 11.1 mmol/l. In contrast, in the rural population, plasma glucose was > 9.0 mmol/l in only 5.5% and > 11.1 mmol/l in less than 1%. There was no evidence that glucose tolerance decreased with age in the two major age groups studied, 18–34 years and 35–54 years (Table 2). There were too few people over the age of 54 to draw conclusions as to glucose tolerance in the elderly, but

Table 2. The frequency distribution of plasma glucose levels two hours after 75 g glucose orally by sex in the age groups 18–34, 35–54 and 55 years and over in 185 urban and 105 rural Papua New Guineas

Urban (n = 185)	Plasma glucose at two hours mmol/l											
	0–6.70		6.71–8.99		9.00–11.09		11.10–16.65		16.66–22.10		22.11–	
Age (years)	M	F	M	F	M	F	M	F	M	F	M	F
18–34 (n = 102)	61	16	4	2	5	0	5	1	3	3	1	1
35–54 (n = 78)	36	8	7	5	5	2	4	3	4	1	2	1
55 + (n = 5)	1	2	1	1	0	0	0	0	0	0	0	0
Total	98	26	12	8	10	2	9	4	7	4	3	2
	124 (67%)		20 (11%)		12 (6.25%)		13 (7%)		11 (6.25%)		5 (2.5%)	

Rural (n = 105)	Plasma glucose at two hours mmol/l							
	0–6.70		6.71–8.99		9.00–11.09		22.11–	
Age (years)	M	F	M	F	M	F	M	F
18–34 (n = 40)	6	25	3	4	0	2	0	0
35–54 (n = 45)	21	20	1	1	0	1	1	0
55 + (n = 20)	7	7	0	4	1	1	0	0
Total	34	52	4	9	1	4	1	0
	86 (82%)		13 (12.5%)		5 (4.5%)		1 (1%)	

regression analysis showed no relation between age and plasma glucose in either population (Table 3).

There was a non-significant tendency for weight to decrease with age in both groups (Table 3). The rural population were on average 10.0 kg lighter than the urban people and taller so that by body mass index both urban men and women were much fatter than their rural counterparts (Table 4). (Weight and mass index were very closely correlated: r = 0.84, p = < 0.0001.) In the urban but not rural population there was a tendency for weight to increase with mild glucose intolerance but, as glucose intolerance increased, weight tended to decrease in both groups so that there were no significant relations between weight and plasma glucose (Tables 3 and 5).

Mean fasting plasma insulin was higher in rural than urban people: rural (n = 102) 19.1 μU/ml versus urban (n = 185) 14.4 μU/ml. The mean fasting plasma insulin of forty Australian adults aged 18 to 65 years determined by the same assay in our laboratory was 10.7 ± 4.5 μU/ml. Fasting plasma insulin was logarithmically distributed, the median and range being; urban 11.0 (range 2– 91) and rural 12.2 (range 2–101) μU/ml. The difference between fasting plasma insulin in the urban and rural population was not significant for the group as a whole. However, if the effect of weight, which tends to raise fasting insulin in both groups (Table 3), is removed by ANOVA analysis, fasting plasma insulin is significantly higher in the rural population (p = < 0.005). This difference is similar if only those people with normal glucose tolerance in both urban and rural groups are compared. Fasting plasma insulin for all Papua New Guinea subjects 16.5 ± 16.2 μU/ml was significantly higher than for Australians (t = 2.17, p = < 0.05) but the urban and rural groups considered separately were not significantly different because of the large variance and an analysis excluding weight was not performed.

Table 3. Correlation coefficients of variables measured in survey (age (years); weight (kg); fasting plasma insulin (FPI) and plasma insulin post-glucose (PI2) μU/ml; fasting plasma glucose (FPG) and post-glucose plasma glucose (PG2) mmol/l). Values underlined have a significance of p < 0.005

Urban (n = 185)						
Age	*–					
Weight	– 0.08	*–				
FPI	0.17	0.16	*–			
PI2	0.02	0.26	0.47	*–		
FPG	0.06	0.08	0.04	– 0.16	*–	
PG2	0.14	0.07	0.16	0.19	0.79	*–
	Age	Weight	FPI	PI2	FPG	PG2

Rural (n = 105)						
Age	–					
Weight	– 0.17	–				
FPI	0.06	0.20	–			
PI2	0.18	0.08	0.30	–		
FPG	0.10	– 0.09	0.38	0.07	–	
PG2	0.08	– 0.13	– 0.12	0.42	0.12	–
	Age	Weight	FPI	PI2	FPG	PG2

Table 4. Mean values with standard deviation for age (years), weight (kg), height (cm), and mass index (weight/height^2 x 10^4) in urban and rural populations

	Urban		Rural	
	Males	Females	Males	Females
	(139)	(46)	(40)	(65)
Age (years)	36.3 ± 10.5	34.4 ± 6.1	43.6 ± 12.0	35.8 ± 11.5
Weight (kg)	70.2 ± 6.7	66.3 ± 8.3	60.6 ± 7.9	57.5 ± 8.5
Height (cm)	161.7 ± 4.3	150.0 ± 5.7	164.4 ± 6.5	157.4 ± 4.6
Mass index	27.1 ± 3.9	29.6 ± 5.5	22.4 ± 2.1	22.4 ± 2.8

Table 5. Weight (kg) according to plasma glucose (mmol/l) two hours after 75 g oral glucose in urban and rural Papua New Guinea populations. The numbers in each group are shown in parentheses

	Two hour plasma glucose mmol/l					
Urban	0–6.7	6.7–8.9	9.0 –11.1	11.1–16.7	16.7–22.1	22.1–
Males (139)	69.8 ± 11.0 (98)	66.5 ± 6.6 (12)	74.1 ± 13.7 (10)	77.7 ± 11.5 (9)	71.4 ± 9.3 (7)	64.7 ± 9.0 (3) kg
Females (46)	64.5 ± 13.8 (26)	69.3 ± 13.1 (8)	64.5 ± 0.7 (2)	77.9 ± 13.4 (4)	64.8 ± 16.2 (4)	59.3 ± 13.0 (2) kg
Rural	0–6.7	6.7–8.9	9.0–11.1			
Males (40)	61.8 ± 7.9 (34)	55.3 ± 2.1 (4)		kg		
Females (65)	55.0 ± 8.0 (52)	61.23 ± 9.1 (9)	50.4 ± 4.9 (4)	kg		

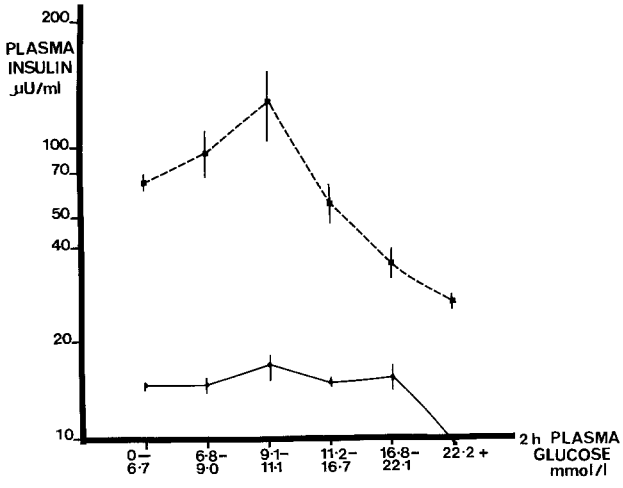

Fig. 1. Plasma immunoreactive insulin (mean ± standard error) by plasma glucose mmol/l two hours after a 75 g glucose load in urban residents of Port Moresby – both fasting (●—●) and at two hours (■- - -■)

Plasma insulin two hours after glucose was also logarithmically distributed and was similar in both urban and rural populations, mean 66.3 versus 69.7 μU/ml. There was a positive correlation of two hour plasma insulin and glucose in the rural group ($r = 0.42$, $p = < 0.001$), but the relation in the urban population fitted a quadratic function with a peak value of insulin release corresponding to a two hour plasma glucose of 11.1 mmol/l and then declining as glucose increased (Fig. 1). Fasting plasma insulin correlated with post-glucose plasma insulin (urban $r = 0.47$, $p = < 0.001$; rural $r = 0.30$, $p = < 0.02$) but was not correlated with plasma glucose (Table 3). In Table 3 the correlation coefficients of the variables measured in the two populations are listed. Fasting plasma insulin was weakly correlated with weight in the rural group; this correlation was significant for women as a whole ($r = 0.36$, $p = < 0.001$) but not for men.

Discussion

This survey has shown that diabetes mellitus is common in some urban Melanesians in Papua New Guinea. The dectected prevalence of glucose intolerance of 22% and of diabetes mellitus of 15.75% was comparable to other reports of a high prevalence of glucose intolerance in Polynesian and Micronesian populations [2, 3, 4, 5, 6]. In contrast, in the rural population both diabetes mellitus and glucose intolerance were uncommon. Although there was a significant difference in the sex distribution between the urban and rural populations; there was no relation of either age or sex to plasma glucose. We believe the difference in glucose tolerance between the two populations is due to other factors and similar differ-

ences have been reported in other countries [10, 11, 12].

Urban men and women, particularly the latter, were very much fatter than their rural counterparts and the lack of a significant correlation of weight to glucose tolerance in the urban people may be explained by the loss of weight due to severe unrecognised diabetes. In contrast to reports from other South Pacific countries [2–6] severe glucose intolerance in relatively young urban people was a feature of this survey. The distribution of plasma glucose following a glucose load did not suggest a bimodal distribution as shown in similar populations with a high prevalence of diabetes [2]. Clinical descriptions of diabetes mellitus in Papua New Guinea have noted the presence of young, non-obese, non-ketotic diabetics who tolerate high blood glucose for a long time [13, 14] and, although obesity is certainly a major aetiological factor, this is an apparent difference from other South Pacific countries.

Fasting plasma insulin appeared to be higher in Papua New Guinea Melanesians than Australians of European descent. Unexpectedly the less obese, more physically active rural people had a higher fasting plasma insulin than the urban population, in whom diabetes was much more prevalent; this was independent of weight. This supports the previous finding that glucose decrease after acute IV insulin was significantly less in non-obese Melanesians with normal glucose tolerance than in Australians [13]. In Micronesians [15] and Polynesians [5] there is a positive correlation of body mass with fasting plasma insulin, as originally described by Bagdade et al. [16], and it has recently been suggested that plasma insulin is higher in women than men [17]. In contrast, only weak correlations between weight and fasting plasma insulin were found in both the urban and rural people studied.

In the urban population there was a positive correlation between plasma insulin and glucose two hours after the glucose load, up to a plasma glucose level of 11.1 mmol/l; at higher glucose levels insulin fell, so that the total relation best fitted a quadratic function. In the rural population only the positive correlation with blood glucose was present. A similar relation has been described in other populations [15, 18] suggesting that with mild glucose intolerance there is an increased output of insulin, but at high levels of plasma glucose, islet cell exhaustion occurs with subsequent insulin deficiency.

Urbanization in Papua New Guinea has only occurred in the last 25 years and has resulted in changes in diet as outlined above and a reduction of regular physical exercise. Neel's thrifty genotype hypothesis [19] provides the most likely explanation of the observed increased prevalence of diabetes which already presents a public health problem that is likely to increase in the future. Microvascular complications have been found in known diabetics in Papua New Guinea and although atherosclerosis appears minimal, gangrene, infection, and renal disease are common [14]. The treatment of established diabetes in developing countries is difficult and there is need for preventative dietary and public health advice. At this stage, a no-sugar diet and regular exercise may reduce the chances of rural Melanesians developing diabetes mellitus.

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